

## Hydrogen Fire in a Storage Vessel

On October 23, 2007, the operations team began a procedure (a written procedure was being followed) to sample the Liquid Hydrogen (LH2) storage vessels (“tanks”), and associated transfer system. This procedure was being performed to determine the conditions within the system, and if necessary, to purge the system of any excess Gaseous Hydrogen (GH2) in preparation for reactivation of the system. The system had not been used since 2003.

The LH2 storage system contains two (2) spherical pressure vessels of 225,000 gallons in volume, with a maximum working pressure (MAWP) of 50 psig. Eight inch transfer piping connects them to the usage point. Operations began with activation of the burnstack for the LH2 storage area. Pneumatic (GN2) systems in the storage area were then activated and checked.

Pressurization of storage tank number 1 with gaseous nitrogen (GN2) was initiated, with a target pressure of 10 psig, at which point samples were planned to be taken. At 5 psig, a loud noise was heard in the upper area of tank number 2. Smoke was seen exiting the burnstack and from the insulation on vent lines for both tanks. At this time tank number 1 was vented and the pressurization system was secured.

The mishap resulted in physical damage to both storage tanks, as well as to some of the piping for both tanks. External to the storage tanks, there was extensive damage to three bellows on a pressurization line, vent line, and instrumentation port due to excessive axial movement. There was also evidence of heat buildup in both vent lines. Significant charring was noted on the tank number 2 external vent line insulation. Internally, extensive damage to the number 2 storage tank was noted. The internal bellows on the manway was distorted and ruptured. The pressurization ring was found lying in the bottom of the tank, where it had fallen after becoming dislodged from its holding brackets. The internal tank personnel ladder was also dislodged and lying against the side of the tank. The three anti-vortex baffles were displaced and the screens were destroyed. There was damage to the inactive level sensor system including cable damage. Tank wall discoloration as well as aluminum and metal slag found in the bottom of the tank and charring of the external vent line insulation indicated a high temperature mishap.

The LH2 tanks and vent system were not properly maintained after the last use in 2003. This allowed hydrogen to remain in the system, providing a fuel source. A fault tree process was used to determine that air entered the system via two possible mechanisms: 1) the vent line was disconnected at several places for installation of new bellows, allowing air to enter the vent line system; and 2) the purge panel was deactivated allowing air to enter the system via the burnstack. During the operation, the hydrogen/air mixture reached a level sufficient to allow combustion, and the flame from the burnstack provided the ignition source. The result was a fire/deflagration that traveled back through the vent line and into the LH2 tanks, causing further fire/deflagration/detonation.

The most probable cause of ignition was determined to be the burnstack pilots, which were active during the mishap. It was determined that a combustible Hydrogen/air mixture most likely reached the burnstack exit and served as a “wick” to ignite the remainder of the system. Check valves and the vent valve in the system could not to arrest a hydrogen flame as it traveled in the vent system towards the tanks.

Corrective action included repair of the damaged hardware by a qualified contractor. Preventive action included documented organizational policy and procedures for establishing standby and mothball conditions for facilities and equipment, including provisions as detailed in the investigation report recommendations:

**Recommendation 1:** The using organization should define necessary activities in order to place hydrogen systems in long term periods of inactivity. The defined activities should address requirements for rendering inert, isolation (i.e., physical disconnect, double block and bleed, etc.) and periodic monitoring.

**Recommendation 2:** The using organization should develop a process to periodically monitor hazardous systems for proper configuration (i.e., a daily/weekly/monthly check sheet to verify critical purges are active).